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An Educational Wildlife Game-based Learning Application for Young Learners Using Augmented Reality

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ABSTRACT

These digital days, the learning curve in the educational sector is changing progressively because of technological advancements and societal demands. Technology integration, particularly, provides the ability to engage in diverse learning platforms, which then expose the learners to an immersive learning experience. This study introduced augmented reality (AR) game-based learning mobile application to young learners in exploring wildlife conservation. However, the challenge in mixing fun gameplay and essential wildlife education to foster young learner's interest in wildlife conservation can be tough. In capturing the attention of young learners, the project aims to create a captivating wildlife game application that combines education with entertainment. This project employs a prototyping method, allowing for iterative development and testing of the AR game application to ensure its effectiveness in delivering educational content. The application incorporates interactive elements such as 3D models of wildlife with vocal features and quizzes elements. Findings reveal that the application facilitated the refinement of game mechanics and educational content based on user feedback, leading to an engaging and educational final product. The results emphasize the success of the approach is not only capturing young learner's interest but also increasing their knowledge and awareness of wildlife conservation. In the future, the incorporation of other elements such as leaderboard, badges and rewards have the potential to stimulate young learners' motivation to actively participate in the learning program.

Keywords: Augmented Reality, education, game application, learning wildlife conservation.

1 INTRODUCTION

The education sector has shifted in relevance to technological advancements through digital platforms, personalized learning, and the development of applications. The focus is on cultivating the abilities of critical thinking and creativity in learning new knowledge through digital environment. By having technology integration, it provides the ability to engage in diverse learning platforms that expose the learners to an immersive learning experience.

One of the current patterns of technology embedded in education is the immersive experience through augmented reality (AR). AR refers to a virtual interface, in 2D or 3D, that enhances (or augments) what we see by overlaying additional information onto the real world, which enables an interactive experience with the real-world objects that are enhanced by computer-generated perceptual information [1][2]. Coherently, AR has been employed in educational contexts to accommodate the learning needs with recommended courses of action, and this technology has left a positive mark on education [2][3]. Since AR pictures models in 3D mode, it raises the value in visualizing the animals, particularly wildlife animals we rarely encountered, and boosting the learning experience in that manner.

In the field of wildlife conservation, some animal species that are very likely to become almost extinct globally or within a specific political jurisdiction are classified as endangered species [4]. The dramatic decrease in the species has become one of the most fundamental issues of our time [5][6]. Thus, to raise awareness and save species from going extinct, it is crucial to learn about endangered species as early as possible.

This study introduced augmented reality (AR) game-based learning mobile application to young learners (age range between 9 and 12 years old) in exploring wildlife conservation. However, the challenge in mixing fun gameplay and essential wildlife education to foster young learner's interest in wildlife conservation can be tough. Moreover, using AR applications can be difficult and time-consuming because they frequently necessitate specialized technical knowledge and setup [7], specifically for young learners that have limited resources. In order to navigate and interact effectively with the augmented environment, AR technology necessitates a combination of digital literacy, spatial thinking, and problem-solving ability [8]. This kind of learning process may take a certain amount of time but is able to seize the attention of young learners.

The project aims to create a captivating wildlife game-based learning mobile application that combines education with entertainment. This application allows young learners to watch animals' settings come to life in front of their eyes, delivering an immersive and participatory experience. They can explore virtual wildlife as if it were right there with them; this type of learning helps them recall and understand things better. It piques their interest, fosters a love of nature, and teaches young learners about creatures and ecosystems in a fascinating way, inspiring a sense of wonder and appreciation for the natural world.

2 LITERATURE

Essentially, Augmented Reality (AR) technology can recognize real-world objects and deliver more information about them, improving the real environment by superimposing digital information on top of it [9]. This can be accomplished by creating applications for tablets and smartphones, which has helped the technology gain popularity and expand [9][10].

2.1 Overview of AR in Education

In education, AR introduces interactive learning experiences by overlaying digital content onto real-world objects, which it can transport learners via a virtual environment, providing them with the

opportunity to experience and gain knowledge [9]. In the past decade, AR in education has thrived through many applications that have accompanied learning processes in all fields and at all levels of education [2][11]. Applications created with the combination of AR hardware and software offered a new way to engage with learners, sparked their interest in learning, yielded academic benefits, and improved the efficiency of the teaching-learning process [10]. Hence, the effectiveness of the learning process was attributed to the adaption of AR technology in the classroom.

2.2 Wildlife Conservation through Applications

Applications using AR technology provide an innovative and engaging platform for educating young learners about wildlife conservation. By incorporating interactive aspects and immersive experiences, the educational impact of the applications, specifically, game can be heightened as it facilitates a more profound relationship with animals and their ecosystems. The use of games and components associated with game reality, content, subject, and imagery in the educational process is currently referred to as "game-based learning" [12]. Moreover, games can provide interactive tasks and activities that help increase young learners' interest in learning new knowledge. It can amuse and educate them at the same time.

In the meantime, the study conducted by [6] examines the viewpoints of high school students regarding endangered species. The study specifically focusses on the identification of endangered animal species, the causes of their endangerment, and the sources of knowledge about them. The results indicate a strong focus on mammalian species. This study focusses on certain categories of mammals based on results data to increase relevance and awareness in wildlife conservation.

2.3 Game-based Learning Applications

In recent years, game-based learning (GBL) has become increasingly significant, as for a young learner, games are a big part of their world. Games are an organic way for them to learn, since learning is an internal process [13]. Through games, the learners can acquire the values, information, and abilities they need to participate actively in both their classroom and community. A variety of forms of games can be used and played in many ways to support educational activities. The easiest way is to use game content as a multiple-choice test, where the game is a reward for learning [12][14].

The research conducted by [12] stated that by implementing game-based learning, learners are much more motivated, demonstrate greater involvement in the process, and also have the intention to continue learning both the subject and the use of game-based learning. The results demonstrated that the use of the game as a means of delivering educational content and the quality of mastering knowledge are relevantly more effective than with ordinary classroom activities.

2.4 Existing Case Study of Wildlife and Educational AR Applications

Recently, applications for AR education in use comprise a wide variety of instruments and systems that make use of AR technology to improve the educational process. These applications may use tablets, smartphones, or specialized AR devices to superimpose digital material on the physical world. A few existing applications related to wildlife conservation using augmented reality are discussed below.

2.4.1 Case Study 1: Application of Zoo AR Photo Service with Animals

In the first case by [15], the zoo AR photo service with animals is a photo service application that requires the use of AR and leap motion technology as a medium to help and make it easy for visitors to take photos and interact with animals in Bandung Zoo. Figure 1 displays the interface implementation carried out on the Zoo AR application of photo services with animals based on augmented reality and leap motion technology.

Figure 1. Interface of Main Menu Application (left), Interface of How to Use Menu (right) [15].

2.4.2 Case Study 2: AR for the Development of Sustainable Tourism in The Chimborazo Wildlife Production Reserve

Next, [16] design a digital product and develop an AR application for the tourism promotion of the Chimborazo Fauna Production Reserve with the use of AR in the reserve, which provides more information and accessibility about the attractions it has for visiting tourists. With the creation of this AR application, it contributes to the tourism sector, offering visitors services that complement their stay, which will provide the information you see, to avoid the overinformation they can find on the internet. In addition, this added value generates diffusion among potential tourists. Figure 2 shows screenshot display of AR application for this study.

Figure 2: Screenshot Display of AR Application for the Development of Sustainable Tourism [16].

2.4.3 Case Study 3: Children Educational Application for Indonesia Endangered Species based on AR

Another quite similar instance with this study, an educational mobile application was created by [17], to educate children about Indonesian endangered species. The application is also empowered by AR to help children imagine and observe the real form of endangered plants and animals. The use of AR technology made it easier for children to observe and imagine the endangered species. Moreover, the use of AR in the education of endangered species would be more fascinating because of its ability to

represent the flora and fauna interactively in real-time. Figure 3 illustrates the screenshot display for main menu and fauna menu of this case study application.

Figure 3: Screenshot Display of Main Menu Application (left), Screenshot Display of Fauna Menu Application (right) [17].

2.4.4 Case Study 4: Adventuring Physics: Integration of Adventure Game and Augmented Reality Based on Android in Physics Learning

On the educational side, [18] develop an educational tool that combines an adventure-style game with augmented reality (AR) to teach physics concepts. [18] design this tool for Android devices with the aim of enhancing student engagement and understanding in physics education. The authors created an adventure game that incorporates AR elements, allowing students to explore virtual environments while interacting with physics-based simulations. The game includes various levels, each designed to teach specific physics concepts such as mechanics, energy, and motion.

2.4.5 Case Study 5: Learn Chemistry with Augmented Reality

Apart from that, [19] focus on the development and evaluation of AR application designed to teach chemistry concepts. The goal of the research is to explore how AR can enhance student engagement, improve understanding of complex chemical structures, and make learning more interactive and enjoyable. The authors aimed to help students better visualize and understand abstract chemical concepts through the use of AR technology and allowed students to view and interact with 3D models of chemical molecules.

2.4.6 Case Study 6: An idea to explore: Use of Augmented Reality for teaching three-dimensional bio-molecular structures

Similarly, [20] propose using AR to teach and visualize complex 3D biomolecular structures. The paper highlights the potential of AR in enhancing students' comprehension of biomolecular models by offering interactive, immersive learning experiences. The paper suggests that AR could serve as an innovative tool for teaching three-dimensional (3D) biomolecular structures. The aim is to improve students' ability to visualize and understand the spatial arrangements and interactions of molecules.

2.4.7 Summary

Overall, the current AR applications program possesses various core functionality and critical features that specifically cater to different target audiences. Based on the above examples, case studies by [15] and [16] has a wider focus on wildlife exploration and tourism. Meanwhile, the [17] mobile application was concurrently quite similar with this project, which focusses on education for children and learning while capturing the idea of preserving wildlife species. Nevertheless, most educational applications recently focused on introducing the endangered species without embedding game-based features.

If we focus more on the educational aspect, there has been a considerable amount of research on developing applications with AR features to support students in learning environments, such as those by [18], [19], and [20]. However, most of these applications concentrate on scientific concepts rather than nature and wildlife, leaving a gap in raising awareness about wildlife conservation issues through mobile applications.

Undoubtedly still, these applications collectively showcase the capacity of AR to captivate learners of any age group and promote educational worthwhileness. The presence of several AR educational tools demonstrates the flexibility and utility of this technology in enhancing interactive and efficient learning settings. This study intends to incorporate several key features from the previous case study to maximize its educational impact. These features encompass the use of AR to explore virtual wildlife animals, educational material about endangered species, and quiz-based elements to enhance motivation and opportunities for wildlife conservation initiatives.

3 METHODOLOGY

This study adopts the prototyping method, as the process entails developing initial prototypes of items or systems to evaluate ideas, collect input, and improve the ultimate solution. This iterative procedure enables the ongoing enhancement and verification of concepts prior to complete implementation [21]. The prototype process provides a versatile approach to building comprehensive projects, particularly when investigating the unfamiliar realm of AR in education. The phases of the prototype model are depicted as below:

3.1 Phase 1: Requirement Analysis

This phase lays the foundation for the entire application development process by highlighting the requirements obtained from literature, establishing the needs and expectations of users, and defining the technical feasibility of game applications for young learners. During the process, system users are interviewed to determine what they expect from the system.

3.1.1 User Requirements

With an emphasis on animal discovery, the application seeks to engage young minds by skilfully fusing education and fun. A primary target audience of young learners between the ages of 9 and 12, the application will be an invaluable resource them to explore the notion of wildlife animals. The study involved 30 elementary school students from Sekolah Kebangsaan Taman Maluri in Kuala

Lumpur. Simultaneously, 14 educators from similar school also participate in this study to tailor on the quiz contents according to curricular objectives. To create effective instructional application, the project first employs a pre-survey method with educators to gain crucial insights into educational preferences and needs. Following this, a post-survey is conducted to collect student feedback, which is then analyzed using the System Usability Scale (SUS) technique.

3.1.2 Technical Requirements

Upon creating this application, several technical requirements must be addressed to ensure a successful project. For platform compatibility, the program should be compatible with the primary mobile and tablet operating systems, particularly Android. Besides, Unity software was used as the primary development platform to create the application. The game employs AR libraries and software development kits such as the Vuforia Engine to enhance the AR experience. Efficient database administration is essential for this project, as it enables the storage and synchronization of user data, quiz results, progress monitoring, and AR material across several devices.

To accomplish this, the project utilizes the capabilities of Unisave and Arango DB, which collectively offer a resilient framework for effective storage and administration of data. A high-end CPU or laptop, was required to build the application, and for testing purposes, Android models covering different Android versions (e.g., Android 10, 11, and 12), diverse screen sizes, and resolutions were needed. Lastly, for AR interaction devices, mobile devices with cameras capable of AR functionalities and a minimum 12 MP resolution, as well as ARCore/ARKit support, are also needed.

3.2 Phase 2: Quick Design

The use case diagram and storyboard were designed to visualize the flow of the system. Use case diagram as shown in Figure 4, consists of two primary actors: 'Educators' and 'Students'. Both actors possess shared functions such as signing in, engaging in games, selecting animal categories, observing animals in augmented reality, and modifying settings, indicating the interactive and instructive aspect of the program. Educators are expected to have the ability to access past scores; however, this feature will not be integrated into the current project.

Figure 4: Use Case Diagram of Project Application

Next, the application's storyboard from Figure 5 views the overall layout and user engagement across different interfaces and features, leading to enhanced effectiveness. Presented below is a thorough overview of the application's storyboard design. At first, users log in, choose categories of animals, and access AR material. The sketch also attaches a set of questions for game-based learning. Initially, the project planned to integrate the leaderboard feature; however, limited time ensues to complete the project; the researcher opts out of this feature, and it will be considered as future work.

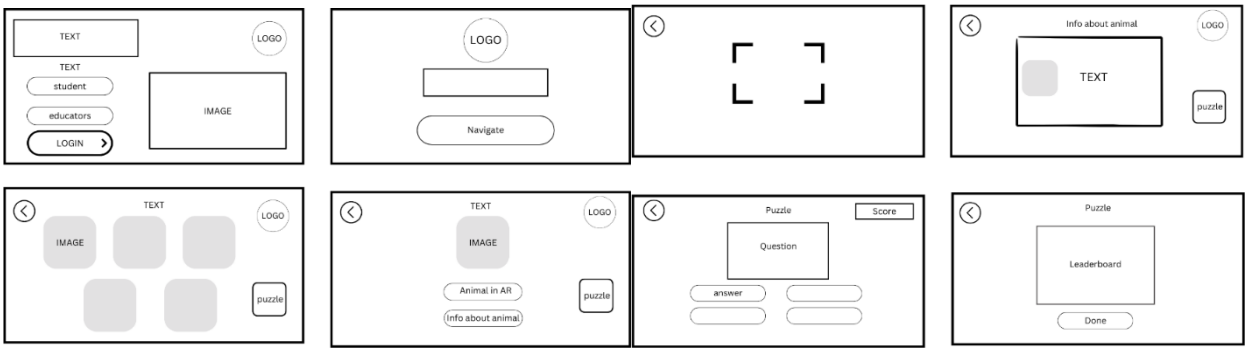


Figure 5: The Storyboard of Project Application

3.3 Phase 3: Build Prototype

The project focusses on developing a prototype application that is specifically tailored to be appropriate and entertaining for young learners. The emphasis of this prototype will be on user-friendly interfaces that incorporate clearly defined buttons, easily adjustable iconography, and engaging animations. At this stage, prototype testing is carried out in educational institutions and with educators to verify that the application conforms to curricular mandates and educational goals.

The researcher conducted a quantitative pre-survey using self-administered questionnaires to collect data from 14 educators on their perceptions of incorporating AR educational games into teaching methods. The findings revealed that 71.4% of educators believe educational games improve student engagement, with 64.3% recognizing enhanced learning outcomes and increased motivation. This suggests the importance of integrating gaming elements into instructional procedures for improved learning outcomes.

Besides, 85.7% of educators mixed resources of educational games into teaching techniques, which shows how educational games are becoming more recognized as useful tools for improving student engagement and learning experiences. There is a broad agreement among educators on how well mixed applications of educational games can improve student learning, of which 64.3% of the educators agreed a noteworthy beneficial influence on the learning outcomes of the students, and 35.7% of educators strongly agreed these instructional game combinations keep students interested and enhance their comprehension of a subject.

3.4 Phase 4: User Evaluation

This stage requires collecting firsthand feedback on the AR experience, identifying areas that need enhancement, and validating its capacity to enhance the user experience. The evaluation involves conducting usability testing in the form of user feedback to evaluate the clarity and engagement of information overlays, as well as to analyze the game's usefulness in facilitating learning.

From a post-survey that was administered to 30 students who had engaged with the application, the students were particularly interested in exploring the 3D animals, as indicated by 36.7% of the participants. Another 40% of the participants clarified that the activities, games, or quizzes were the most preferred component. In addition, 13.3% of the participants expressed a liking for taking virtual tours, while 10% preferred to discover new things. This distribution demonstrates a particularly important proximity when the materials' composition consists of interactive and visually appealing elements that effortlessly capture young learners' attention. Furthermore, 70% of the 30 students indicated that they have acquired a substantial amount of knowledge about animals or nature through the application. An additional 26.7% of respondents indicated that they gained knowledge from the material, while 3.3% reported that they did not learn anything new about animals. A few individuals may already be knowledgeable about animal information.

On the other hand, 13 individuals, representing 43.3% of the total, found this application completely clear, but 14 individuals (46.7%), expressed slight uncertainty with this application, and 10% found certain sections of the content to be perplexing, including the instructions on changing the channel and initiating the game with the animal viewing component. It is possible that these young learners still need the assistance of technical personnel to navigate this system. Nonetheless, 21 students, or 70% of the sample, strongly agree that this system is easy to use, with 16.7% of the sample expressing a neutral opinion regarding the ease of use of this system, and 13.3% of respondents agreed that this application is user-friendly.

3.5 Phase 5: Refining Prototype

The feedback obtained from users during the initial user evaluation phase was to pinpoint areas that necessitate enhancement and to validate the potential of the AR experience in augmenting the user experience. The feedback also gathered to iterate on the design and functionality until the required level of quality is attained. The researcher considers any potential obstacles and measures to minimize the impact that were identified throughout the investigation to ensure the project's success. The purpose of the prototype refinement phase is to develop a captivating and pedagogically impactful wildlife game application for students, at times utilizing AR technology.

3.6 Phase 6: Implement and Maintain

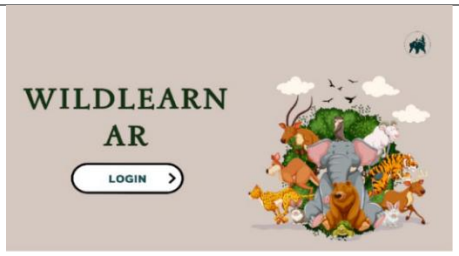
After the completion of the finished system, it undergoes comprehensive testing to verify its compliance with the intended standards of quality and functionality. Subsequently, the system is implemented in the actual environment, where it oversees the system's operation, detecting and addressing any problems, and implementing updates to assure its ongoing relevance and efficiency.

4 RESULTS AND DISCUSSIONS

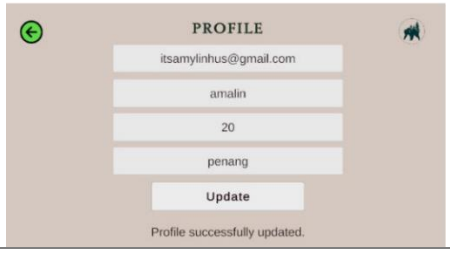
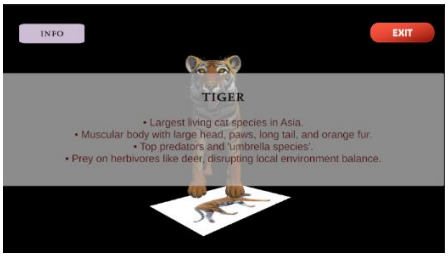
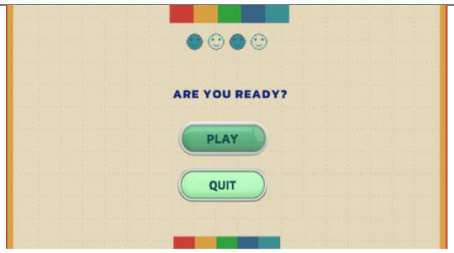
An educational wildlife mobile application was developed with the integration of AR elements using Unity and Vuforia software. The code utilized in Unity as such is scripting for an email authentication panel to handle registration and login procedures, guaranteeing safe user authentication using the Unisave backend. Then, a user profile maintenance script, which enables users to easily access and change their personal data. The additional script implemented for essential elements enhances the AR experience by facilitating scene changes based on specific animals. Also, the scripting to construct the quiz administration features that creates an interactive learning environment by managing quiz questions, user input and scoring.

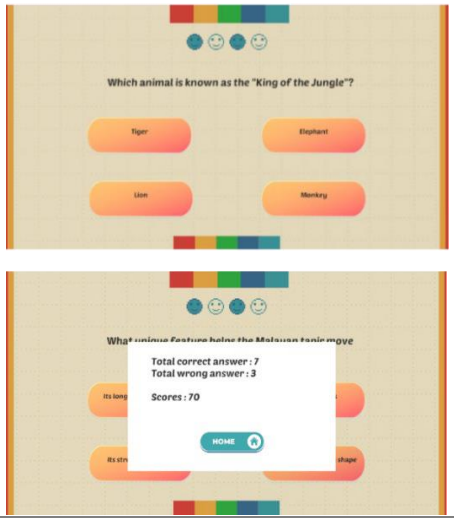
The application named WildLearn AR for this study has the intention of placing primary emphasis on user interface simplicity while also ensuring an aesthetically pleasing appearance. The researcher employed distinctive buttons, sizable iconography, and captivating animations as key design principles. The goal was to create the application in a manner that would enhance the student's comprehension and engagement in the learning process. Table 1 depicts thorough descriptions of each interface of this application.

Table 1: Descriptions of Project Application's Interface Design

Screen	Screenshot	Descriptions
Main page		On the initial screen, located in the middle of the screen, is a bold font displaying the headline "WILDLEARN AR". The main page prominently displays the image, which showcases various exotic species, thereby enticing viewers to open the app. The template is primarily centred around a prominent "LOGIN" button, which allows users to easily navigate to the login page.
Login page		The login screen page is the interface where a user enters their email and password to access and utilise the application. The layout is well-organized and has two input fields: email and password. At this login page, you will find a login button followed by a registration option for new users.

Register page		The registration screen page allows anyone to establish an account on this application. The information includes "Username", "Age", "Place of Birth", "Email", "Password", and "Confirm Password". Prior to establishing an account, users are required to peruse and consent to the privacy policy.
Success Registered page		It is shown on the screen once a user has successfully logged into the application. This application allows users to log in to the system using the email address, which is automatically populated by the system.
Success authentication page		Once the user has successfully logged in, this success authentication page will show, indicating that the user can click the "Tap to Start" button.
Homepage		The user is greeted with a welcome message at the top of the homepage. This is followed by instructions in capital letters to choose the wild animal. Each subtopic includes animal photos. The user can select a specific animal, such as a barking deer, Malayan tapir, lion, tiger, sunbear, kangaroo, and elephant, by tapping on any photo. Afterwards, there is a button labelled "EXIT" that allows users to log out of the system.
Profile page		This profile screen page is displayed to a user upon completion of profile setup and account creation. It also allows users to alter their details. The text area widget showcases the user's email address, username, age, and place of birth. Users can click on the “Update” button to save any changes they have made to their profile fields.

Updated profile page		Upon clicking the “Update” button, a message notice stating “Profile successfully updated” will be displayed below the button to confirm to the user that the change has been made.
Animal page		Expanding on the previously chosen animal, this screen page presents the selected animal in a more detailed and thorough way. The interface features a central image of the selected animal, accompanied by navigation buttons, allowing users to switch to other animals. Directly beneath the picture, there is a line displaying the name of the animal. Users are provided with a "VIEW IN AR" button that allows them to activate AR view and see a 3D model of the animal in the actual environment. In addition, the “QUIZ” button is positioned at the bottom for accessing related quizzes.
AR animal page	 	By selecting the "View in AR" option, the user is required to initially scan the image of the animal to access the 3D model of the chosen animal. Subsequently, a three-dimensional representation of the animal with vocal feature will materialize, allowing the user to control their phone to examine the precise structural features of the creature. The "INFO" label, positioned at the upper left, is most likely intended to provide supplementary details about the selected animal. Once the viewer has finished viewing the 3D animal and reading the provided information, they can click on the "EXIT" button to leave the screen and return to the previous menu.
Quiz section page		Upon clicking the Quiz button, it will redirect the user to the Quiz section page. Users can respond to a quiz on this platform. There are ten questions that need to be answered. The purpose of this screen is to initiate the game by presenting

		the user with options to either commence playing or exit the game.
Quiz scores section page		Once clicking the PLAY button, a multiple-choice question about the animals will be displayed. If the learner provides a proper answer, the message will be displayed containing an exemplary text for the accurate response. The final screen provides a comprehensive overview of the player's performance, displaying the total number of correct and incorrect answers, as well as the score. Additionally, it has a "HOME" button that allows the user to navigate back to the main screen.

As mentioned, the System Usability Scale (SUS) analysis was carried out following the application's implementation to get user input on the features and interface. In summary, it was found that 70% of respondents said the user had the best possible experience with the application. Additionally, 17 out of 30 students stated that they will utilize this system consistently, which allowed them to learn more new information about nature and animals. Positive perspectives on the most preferred attributes also describe how well AR components direct attention to the captivating manifestations. Thus, it is possible to identify the application's most salient features by looking into the results that users have submitted, of which 36.7% of participants said they found it enjoyable to view 3D animals, and 40% said they enjoyed doing quizzes through the game-based learning application.

5 CONCLUSION AND RECOMMENDATIONS

Encouraging young learners to learn about endangered species is essential, as it can indirectly raise awareness of species conservation at an early age, helping to prevent intentional extinction of species by humans. The development of this educational AR tool not only imparts knowledge but also fosters a sense of awe and compassion for the natural world. This project provided an immersive experience for young learners by using AR to showcase wildlife and ecosystems. Information about various animals and their habitats made the content instructive and informative. The vibrant and interactive user interface, together with additional elements such as animal virtual contents and quizzes, engaged young learners' curiosity on the application while providing an enjoyable means of learning.

By engaging in these experiences, young learners not only acquire information about these extraordinary creatures but also develop a strong commitment to their protection, thus making valuable contributions to the preservation of our wildlife animals. This project combines AR technology with wildlife education to ensure that learning is both enjoyable and cultivates a profound bond with the natural world. Through the features of AR, young learners could view exotic creatures

in a captivating and unforgettable manner. These immersive activities not only deepen comprehension but also inspire a fervour for animal preservation among them.

Likewise, AR used in this application allows for interactive and immersive learning experiences whereby students can visualize animals in 3D, which can enhance understanding and retention. AR can also serve as a powerful tool for educators, providing them with interactive resources that can enhance their teaching methods and lesson plans. This continued advancement in AR technology could lead to even more sophisticated educational applications in the future, further enhancing educational experiences. Overall, the integration of AR into educational technology offers exciting possibilities for enhancing learning experiences, personalizing education, and supporting both students and educators.

As for future work, the incorporation of elements such as a leaderboard, badges, and rewards have the potential to stimulate students' motivation to actively participate in the program. Besides, engaging narratives that include youngsters in tracking endangered species through different challenges might enhance their involvement and ability to remember information. Integrating sophisticated functionalities like voice commands, real-time feedback, and immersive 3D animated creatures accompanied by sound would elevate the user experience and foster greater engagement. These improvements will boost the application's entertainment and instructional value for young users.

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